SOIL SURVEY OF THE BILLINGS AREA, MONTANA.

By CHARLES A. JENSEN and N. P. NEILL.

LOCATION AND BOUNDARIES OF THE AREA.

The Billings area is in the Yellowstone Valley a little east of the central part of the State at approximately 45° 45′ north latitude and 108° 30′ west longitude. It extends from about 1 mile east of Billings to 1 mile west of Park City, a distance of nearly 25 miles. At Billings the area is about 4 miles wide, and it gradually becomes wider westward until at a distance of about 8 miles west of Billings the maximum width of 7 miles is reached. It then suddenly narrows to about 3 miles, which width it approximately maintains to Park City. It is

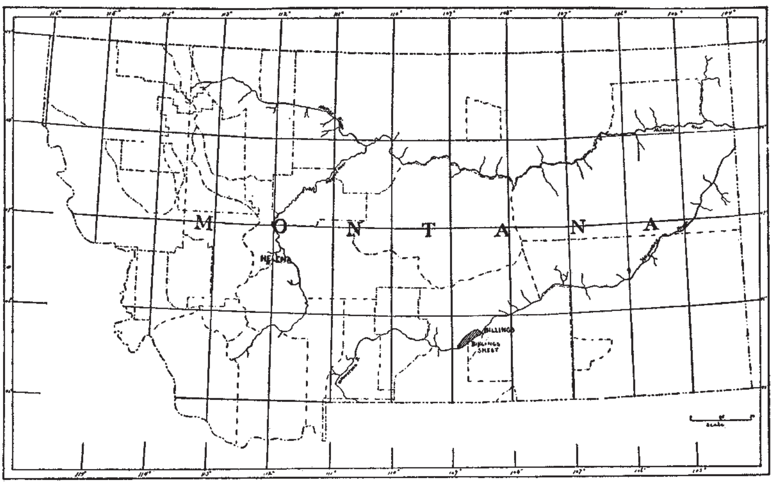


FIG. 20.—Sketch map showing area surveyed in Montana.

bounded on the north by the Highland Ditch and the Minnesota and Montana Improvement Ditch, which follow the sandstone bluff quite closely, and on the south by the Yellowstone River, which flows in a northeasterly direction. The area comprises 68,416 acres, or about 107 square miles.

HISTORY OF SETTLEMENT AND AGRICULTURAL DEVELOPMENT.

The earliest known visit of white men to the region now in part the State of Montana was early in the nineteenth century, when a number

of Jesuit missionaries made their way into the country. For some time after that trapping and fur trading formed the chief occupation of the transient whites. In fact, this was the chief industry until comparatively recent times.

The present boundaries of Montana were not established until 1864, and at that time the State was simply one large cattle range, open to anyone who wished to enter it. Mining was one of the first industries of the State to be developed, and it is to-day one of the most important.

Agriculturally speaking, Montana is very young, and Yellowstone County is one of the latest areas brought under cultivation. The county was organized in 1883, before which time the area formed a part of Gallatin and Custer counties, comprising most of the Crow Indian Reservation. Billings, the county seat, was founded in 1882. The Crow Indians were usually friendly to the white settlers, but the Nez Perces Indians made a raid in 1880, doing considerable damage to stockmen and some of the few other settlers. Aside from this, Yellowstone County has had but little trouble with Indians.

The first known attempts at agriculture were necessarily on a very small scale. In the area surveyed the earliest cultivation of crops was near the confluence of Clark Fork Creek and the Yellowstone River in 1869. Farming, however, was not considered seriously until the extension of the Northern Pacific Railroad into the valley in 1882. The construction of irrigation ditches then began in earnest, and agriculture made rapid growth. The development has been even more rapid since 1890.

The large and much used stock range adjoining the area has been an important factor in promoting agriculture in the valley. Considerable shipments of beef cattle, horses, and sheep are made at the various stations in the valley, being especially heavy at Billings.

CLIMATE.

The south-central part of Montana is semiarid. The 12 inches of rainfall occurring annually in the area surveyed, while not enough for agricultural purposes, very materially aids irrigation, as much of the rainfall comes in May and June. In some seasons the spring rains are sufficient to mature the first crop of alfalfa, and usually one irrigation is enough for the first crop, save in exceptionally dry seasons. During the months of July and August irrigation must generally be practiced. The surrounding ranges receive more rainfall during the season than the valley, which fact is of great importance to the stock interests.

The following table gives the normal temperatures recorded at the Weather Bureau station at Billings. Unfortunately, no record of the rainfall is available.

Normal monthly and annual temperature.

Month.	Billings.	Month.	Billings.
	° *F.*		° *F.*
January	24.4	August	69.3
February	26.5	September	58.6
March	31.1	October	51.5
April	50.5	November	30.8
May	57.9	December	28.9
June	62.9	Year	47.0
July	72.6		

During the summer months the temperature sometimes exceeds 100° F., but the nights are almost invariably cool. During the winter 20° or 25° below zero is sometimes reached, though much lower temperatures, which must be regarded as rather exceptional, are on record. As a rule, considerable snow falls throughout the immediately surrounding country, but during the last two years the snowfall has been quite light.

The wind movement is not generally high; the average for the year would be low, but occasional hailstorms, with strong winds, occur during the spring and early summer, damaging the crops. In one season the grain crops were practically destroyed by hail.

Frosts in spring are not late enough to cause any appreciable damage to the crops at present grown in the area. The average date of the last killing frost in spring, based on the records of six years at Billings, is May 12, and the first in fall September 7.

PHYSIOGRAPHY AND GEOLOGY.

As the part of the Yellowstone Valley surveyed is situated east of the base of the Rocky Mountains, there are no high mountains immediately surrounding the area such as usually hem in the valleys in the intermountain country. The hills surrounding the area are a line of sedimentary ridges rising to a height of from 200 to 500 feet above the valley floor. The sandstone bluffs exposed on the north side, near Billings, consist of medium-grained siliceous sand from 0.5 to 0.1 millimeter in diameter, while the bluffs exposed opposite, on the south side, are of fine-grained, well-laminated shale of a dark color, called Fort Benton shale. The sedimentary deposits are of cretaceous origin and were laid down in salt water—a fact proven by the character of the contained fossils and the comparatively large amount of salt which, in the shale especially, is often found in veins parallel to the bedding.

The Fort Benton shale occurring on the south side of the valley underlies the sandstone on the north side. This is not shown in the

outcrop at Billings, but is plainly seen in the gullies on the north side of the valley, near Laurel.

Through this sedimentary material the Yellowstone River has cut its way, forming the valley. The sandstone beds in this process were almost, if not entirely, washed away, leaving the shale as the river bed, which can be seen outcropping in a number of places in the abandoned river channels. Since the sedimentary beds were deposited the river has had a number of courses before the present one was selected, and in its meandering it has left considerable waterworn gravel strewn over the surface of the hill slopes of the valley. A very general bed of gravel was also deposited throughout the valley, which has since been covered with soil transported from the hills on the south.

The sandstone bluff on the north side, while appearing as a bluff or a ridge from the valley, really forms the boundary of a plateau covered with a thick layer of soil which, were irrigation possible, would be good farming land. To the south the country is more hilly.

The sandstone is quite porous and readily permits the penetration of water, which follows the planes of bedding, bringing with it in solution the salts which often crystallize out on the perpendicular walls. The shale to the south is finer in texture, shows the sedimentary bedding very distinctly, and can be easily separated along the planes of bedding into very thin sheets. The shale contains considerably more included salts than the sandstone, and beds and veins of gypsum are common. The sandstone is used to some extent for building. Owing to the coarseness of some of the stone and the included salt, care must be exercised in selecting it for such purpose, as the ground water readily disintegrates the coarser material when used for foundations.

Some of the disintegration products of the shale are claimed to be excellent material for the manufacture of tile, but this industry has not yet been developed.

The gravel terrace extending from Billings to Laurel is a former bank of the river.

The physiographic features of the valley are very simple. The northern boundary of the valley is sharply defined by the sandstone bluff. About 1 mile west of Billings a ridge or bench leaves the bluff and takes a southwesterly direction, again joining the bluff at Laurel. At this place the bluff projects quite far northward, making the valley there much narrower than at or west of Billings. This bench is from 10 to 30 feet high and forms a level plateau. The maximum width of this plateau between the ridge and the Highland Ditch is about 4½ miles and its length is about 14 or 15 miles. At about 3 miles west of Laurel another bench gradually forms and again gradually disappears near Park City. This bench forms but a small plateau of about the same height as the larger one just mentioned. South of these plateaus is another level area, which extends to the alluvial soils

along the river, sloping very gently, almost imperceptibly, in that direction. This area has a maximum width near Billings of about 3½ miles, and from there to Park City varies from 1 mile to 2½ miles in width. The ridge separating these level areas is steep and gravelly.

The alluvial area along the river is from a few feet to 10 or 15 feet below the adjoining areas, and, with the exception of a few shallow channels and draws, it is quite level. The area varies from 1 to 1½ miles in width.

SOILS.

The soils of the area were separated into five different types, as follows: Billings clay, Billings loam, Billings sandy loam, Billings gravelly loam, and Laurel sandy loam.

The subjoined table gives the areas of the soils and the percentage which each is of the total area:

Areas of different soils.

Soil.	Acres.	Per cent.	Soil.	Acres.	Per cent.
Billings clay	17,088	25.0	Laurel sandy loam	8,832	12.9
Billings loam	14,144	20.7	Swamp	3,008	4.4
Billings sandy loam	13,568	19.8	Total	68,416	
Billings gravelly loam	11,776	17.2			

BILLINGS CLAY.

As mapped, the Billings clay consists of from 0 to 12 inches of clay loam, underlain by clay 3 to 12 feet in depth, which is in turn underlain by sandy loam, sand, or gravel, though the last is not often found. The clay is dark gray to black, sometimes mottled, tough and sticky, and contains, so far as noticeable to the touch, little or no sand. The clay itself is often 10 to 12 feet deep, and in such cases is practically impervious to water. It packs very firmly in roads and pastures and becomes very hard when it dries. It is locally known as "gumbo." This soil is quite generally distributed over the area, both on the upper plateau and the lower level area between the gravel terrace and the alluvial soils along the river. It is all nearly level, excepting the gentle slopes near some of the foothills. None of it extends near enough to the river to be at all subject to overflow. Generally speaking, the drainage of the areas of this type is poor, and when once the deep-clay areas become saturated with water and subsoil water nears the surface it is a difficult matter to remove it, owing to the close texture of the soil. In the areas having sandy loam or sand underlying the clay at a depth of 2 or 3 feet the drainage is fair and could easily be improved. Such areas generally contain less alkali than the deep-clay areas.

Billings clay owes its origin both to the disintegration of the Fort Benton shale in place and to the transportation of the same disinte-

grated material. In the lower portion of the valley the first method and in the upper portion the latter method of formation probably prevailed. The small streaks or strata of sand and sandy loam occasionally found are due to transportation of disintegrated sandstone, the latter overlying the shale. As the shale contains considerable quantities of salts, the same is generally true of the derived soils.

The clay is difficult to cultivate to grain crops and if tilled a little too wet forms a very undesirable surface, the clods baking very hard. The surface also becomes very hard when drying after a rain, a very hard crust forming over the entire surface. When not too alkaline this soil is generally well adapted to timothy, blue joint, redtop, June grass, and other grasses. The areas underlain by sandy loam or sand at 3 feet or so are well adapted to alfalfa, though this kind of soil is not as good for alfalfa as the lighter types.

The following table shows the texture of typical samples of this soil:

Mechanical analyses of Billings clay.

No.	Locality.	Description.	Organic matter.	Gravel, 2 to 1 mm.	Coarse sand, 1 to 0.5 mm.	Medium sand, 0.5 to 0.25 mm.	Fine sand, 0.25 to 0.1 mm.	Very fine sand, 0.1 to 0.05 mm.	Silt, 0.05 to 0.005 mm.	Clay, 0.005 to 0.0001 mm.
			P. ct.	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*
6727	¾ mile W. of NE. corner sec. 1, T. 1 S., R. 25 E.	Heavy loam, 0 to 12 inches.	0.97	0.00	0.20	0.32	14.22	15.60	37.80	31.54
6721	¾ mile N. of S. corner sec. 19, T. 2 S., R. 24 E.	Clay, 0 to 12 inches..	1.07	.14	.56	.98	3.26	8.24	45.08	40.56
6729	Subsoil of 6727......	Clay loam, 48 to 60 inches.	.44	.14	.24	.26	10.32	13.94	39.06	35.42
6723	Subsoil of 6721......	Clay, 48 to 60 inches.	.16	.26	1.40	3.22	5.26	8.00	38.00	43.76
6728	Subsoil of 6727......	Clay, 24 to 36 inches.	.36	.00	.08	.20	9.40	13.10	29.66	46.88
6722	Subsoil of 6721......	....do..............	.36	.10	.46	.60	1.92	5.48	43.64	47.72

BILLINGS LOAM.

The Billings loam consists of 0 to 12 inches of loam, underlain by a light clay loam to a depth of from 2 to 6 feet, which is in turn underlain by sandy loam or sand, and occasionally, though not frequently, by gravel. Part of the area mapped as Billings loam has a surface covering of sandy loam, but practically the only place where this occurs is in the area west of Billings under the gravel terrace.

The Billings loam is gray to black in color, with the same properties, in a less degree, as the Billings clay. It contains generally enough coarse sand to give it a gritty feel. It cultivates quite easily, giving a much more pulverant surface than the clay, and does not

form so hard a surface when drying after irrigation or rain as the heavier soil.

The Billings loam is found adjoining the Billings clay and Billings sandy loam areas, being quite generally distributed on the upper plateau and around Billings. Like the Billings clay areas it is level.

The underground drainage of this type is generally better than that of the Billings clay, due both to its lighter texture and to the underlying sandy loam or sand and occasional gravel. Much of the area could, however, be considerably improved in this respect, especially that near the center of T. 15 S., R. 25 E.

The Billings loam owes its origin to a mixture of the disintegration products of the Fort Benton shale and the sandstone on the north side of the valley, and thus the texture ranges between sandy loam and clay.

This soil type is adapted to grain and vegetables, especially in the areas with sandy loam surface. It is, however, better adapted to alfalfa and other grasses, such as timothy, blue joint, redtop, etc. Fruit trees are doing fairly well on some areas of this type.

The Billings loam contains some alkali, though not as much as the Billings clay. This will be considered in the chapter on "Alkali in soils."

The following table shows the mechanical composition of this type:

Mechanical analyses of Billings loam.

No.	Locality.	Description.	Organic matter.	Gravel, 2 to 1 mm.	Coarse sand, 1 to 0.5 mm.	Medium sand, 0.5 to 0.25 mm.	Fine sand, 0.25 to 0.1 mm.	Very fine sand, 0.1 to 0.05 mm.	Silt, 0.05 to 0.005 mm.	Clay, 0.005 to 0.0001 mm.
			P. ct.	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*
6713	¼ mile S. of NW. corner sec. 16, T 1 S., R. 25 E.	Loam, 0 to 12 inches.	1.56	0.04	0.54	0.50	8.38	18.22	40.42	30.93
6714	Subsoil of 6713......	Light loam, 24 to 36 inches.	.30	.00	.16	.48	10.24	18.88	44.30	25.44
6715	.....do..............	Sandy loam, 48 to 72 inches.	.36	.30	.62	.92	11.96	22.76	33.80	29.14

BILLINGS SANDY LOAM.

The Billings sandy loam consists of 0 to 12 inches of loam, underlain by a light-yellow sandy loam to a depth of from 3 to 15 feet, which is in turn underlain by sandstone fragments, gravel, or sand. When approaching loam in texture it becomes a little adhesive. It packs well in roads but tills very easily, forming a very well-pulverized surface. This soil occupies the gentle slopes of the foothills of the sand-

stone bluff and is seldom found on the lower levels. It is derived from the transported material of the disintegrated sandstone on the north side of the valley. Below the slope of the foothills it gradually becomes heavier, being mixed more or less with the loam or clay derived from the shale underlying the sandstone.

The underdrainage of this type is good, and injurious amounts of alkali are not present except in one small area.

This soil is well adapted to any crop suited to the climate of the valley.

The following table gives the results of mechanical analyses of this soil type:

Mechanical analyses of Billings sandy loam.

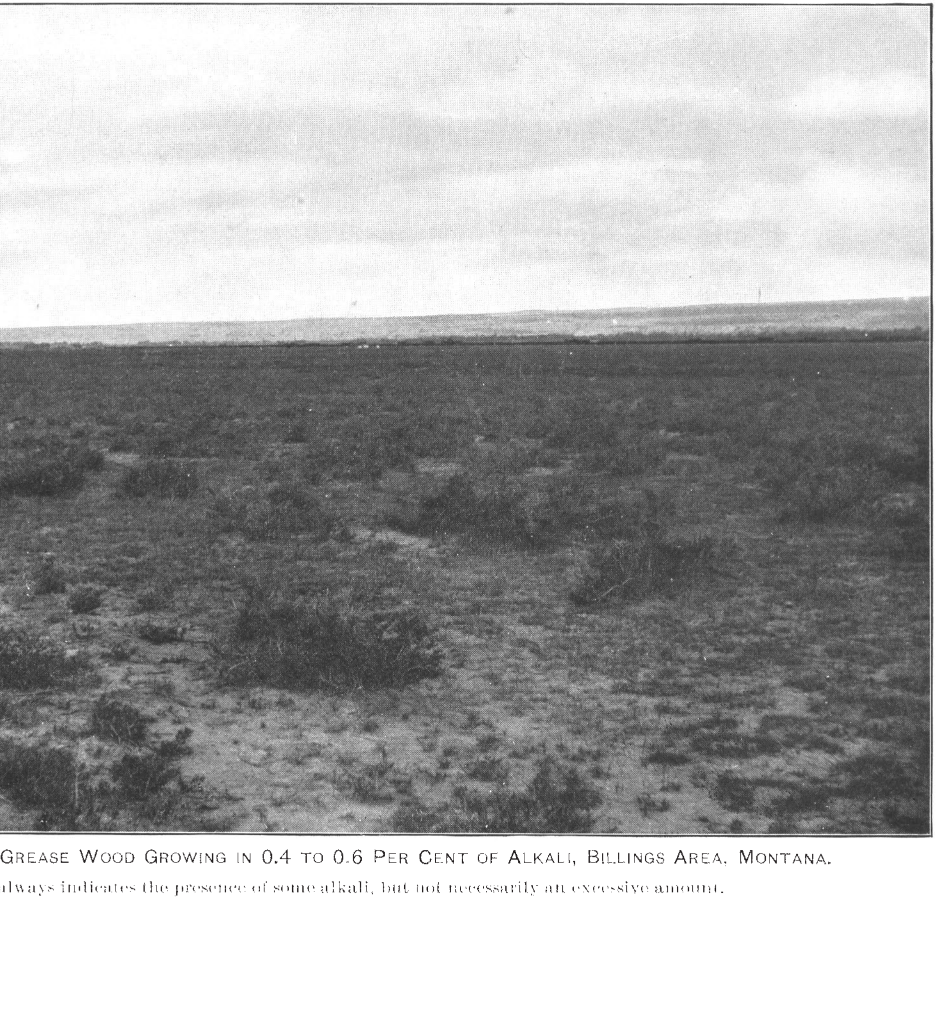
No.	Locality.	Description.	Organic matter.	Gravel, 2 to 1 mm.	Coarse sand, 1 to 0.5 mm.	Medium sand, 0.5 to 0.25 mm.	Fine sand, 0.25 to 0.1 mm.	Very fine sand, 0.1 to 0.05 mm.	Silt, 0.05 to 0.005 mm.	Clay, 0.005 to 0.0001 mm.
			P. ct.	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*
6716	¼ mile NW. corner sec. 2, T. 1 S., R. 25 E.	Sandy loam, 0 to 12 inches.	1.18	0.00	0.50	0.90	30.34	30.64	22.48	14.54
6718	Subsoil of 6716......	Fine sand, 48 to 60 inches.	.29	.00	.24	1.30	43.48	32.44	12.40	9.58
6717	.....do..............	Fine sand, 24 to 36 inches.	.69	.00	.28	.70	38.44	35.52	12.94	11.64

LAUREL SANDY LOAM.

The Laurel sandy loam is an alluvial sandy loam soil, from 2 to 6 feet or more deep, underlain by gravel. Usually the sandy loam grades into sand at lower depths. In color it ranges from a light yellow to nearly black, the soil containing usually much organic matter.

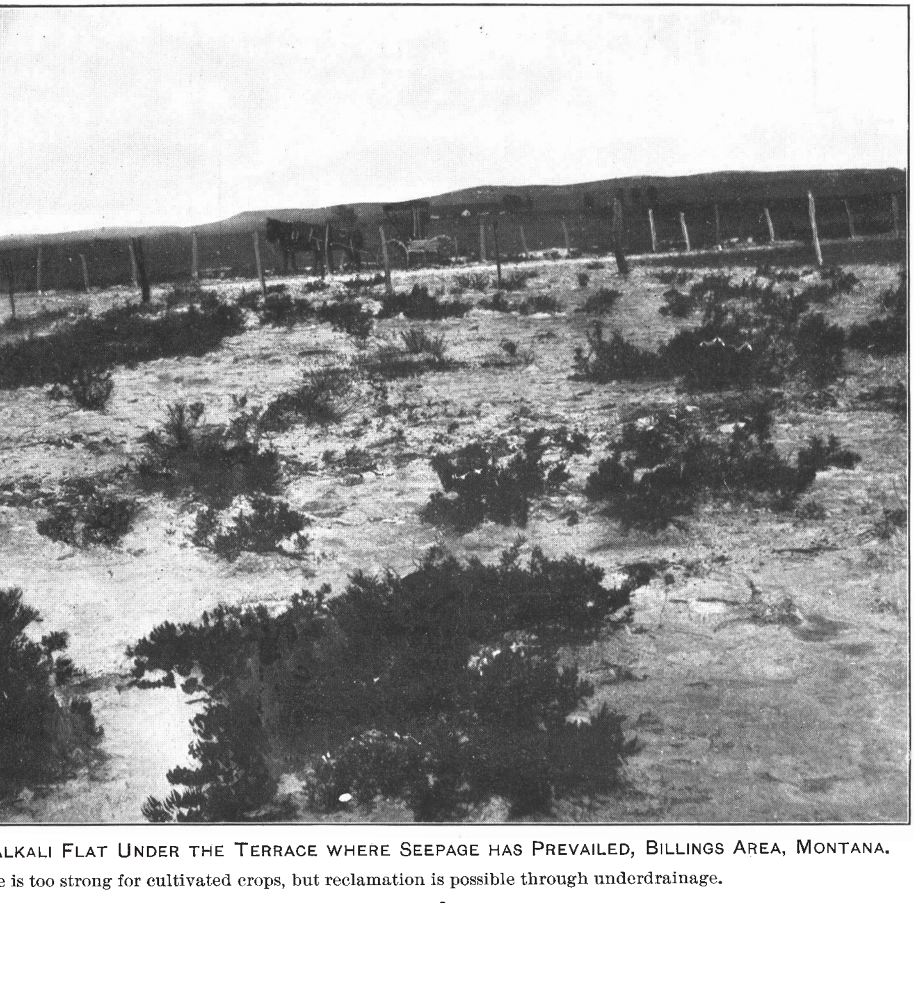
The largest body of this soil occurs east of Park City, stretching eastward in long strips of varying width and separated from the river usually only by the Billings gravelly loam. Another large area lies along the northern border of the area surveyed, branching at a point in sec. 3, T. 3 S., R. 2 E., one fork extending some distance farther north and east along the border and the other occupying a middle course through the valley to within 4 or 5 miles of Billings.

The surface of this soil type is usually level, but it is intersected in many places by sloughs and old river channels, and there are many swampy areas, due to seepage from irrigating ditches. As may be inferred from this, the general drainage of the type is not good, although it could easily be made so, as the subsoil is light and rests upon gravel. In some places the gravel even reaches to the surface. The natural drainage is better in those areas nearer the river.



GREASE WOOD GROWING IN 0.4 TO 0.6 PER CENT OF ALKALI, BILLINGS AREA, MONTANA.

lways indicates the presence of some alkali, but not necessarily an excessive amount.



ALKALI FLAT UNDER THE TERRACE WHERE SEEPAGE HAS PREVAILED, BILLINGS AREA, MONTANA.

e is too strong for cultivated crops, but reclamation is possible through underdrainage.

The Laurel sandy loam owes its origin to the Yellowstone River, being composed of deposits of material carried by that stream when it flowed in other channels than the present one.

This soil is the only one in the area found to contain black alkali. The presence of this salt is due largely, if not wholly, to the seepage waters which flow from the higher-lying lands. The part of the area nearer the river, being the better drained, contains less alkali than those parts more remote from the river.

When unaffected by alkali this soil is excellent for grain, vegetables, alfalfa, clover, and fruit.

The following table shows the mechanical composition of the Laurel sandy loam:

Mechanical analyses of Laurel sandy loam.

No.	Locality.	Description.	Organic matter.	Gravel, 2 to 1 mm.	Coarse sand, 1 to 0.5 mm.	Medium sand, 0.5 to 0.25 mm.	Fine sand, 0.25 to 0.1 mm.	Very fine sand, 0.1 to 0.05 mm.	Silt, 0.05 to 0.005 mm	Clay, 0.005 to 0.0001 mm.
			P. ct.	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*
6730	SE. corner sec. 10, T. 1 S., R. 26 E.	Sandy loam, 0 to 12 inches.	1.36	Tr.	0.42	1.54	24.48	34.74	29.66	9.58
6733	Near SW. corner sec. 13, T. 2 S., R. 24 E.	Sandy loam, 0 to 12 inches.	1.84	0.30	2.56	4.44	21.44	26.46	31.48	13.28
6732	Subsoil of 6730......	Sandy loam, 48 to 60 inches.	.69	.00	.66	4.50	35.34	29.38	20.90	9.02
6731	Subsoil of 6730......	Sandy loam, 24 to 36 inches.	1.12	.10	.30	2.20	32.74	21.72	30.48	12.42

BILLINGS GRAVELLY LOAM.

The Billings gravelly loam is a sandy loam of the same composition as Billings sandy loam, having a depth of 0 to 18 inches and being underlain by loam or light clay loam of the same kind as found under the other soils of the area and about 3 feet in depth. Beneath this occurs a bed of waterworn gravel, which comes to the surface over most of the area mapped as gravelly loam.

This soil is generally found on or near the terraces, which were former river banks, most of the soil having been removed from these places by transportation, leaving the gravel outcrops. It is free from alkali and well drained.

Near the edge of the terraces it is of little or no agricultural value, being too gravelly, but farther back on the plateau it is well adapted to grain, vegetables, and alfalfa.

14117—03——43

Mechanical analyses of Billings gravelly loam.

[Fine earth.]

No.	Locality.	Description.	Organic matter.	Gravel, 2 to 1 mm.	Coarse sand, 1 to 0.5 mm.	Medium sand, 0.5 to 0.25 mm.	Fine sand, 0.25 to 0.1 mm.	Very fine sand, 0.1 to 0.05 mm.	Silt, 0.05 to 0.005 mm.	Clay, 0.005 to 0.0001 mm.
			P. ct.	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*
6719	SW. corner sec. 23, T. 2 S., R. 23 E.	Loam, 0 to 14 inches.	1.57	0.52	3.84	6.48	13.66	22.96	28.42	24.04
6720	⅛ mile N. of W. center sec. 27, T. 2 S., R. 23 E.	Loam or clay loam, 0 to 14 inches.	.80	.10	1.00	1.78	9.04	16.62	43.48	27.48

SWAMP.

A number of small places throughout the area have been so saturated with seepage water or by excessive irrigation that they have become tule swamps or marshes with free water standing on the surface. These places were mapped as swamp and are of no present agricultural value, being generally too wet even for pasturage. The soil texture of these is generally that of the surrounding soils. They are generally situated immediately below gravel terraces, where seepage water naturally first affects the land.

WATER SUPPLY FOR IRRIGATION.

There is an abundance of irrigating water in the area surveyed; in fact, much more than the present canal system can use, and undoubtedly more than necessary to completely irrigate the whole valley. The supply comes from the Yellowstone River, which has its source in Yellowstone Lake, in Wyoming. This lake, which is constantly fed by springs and the melting of the snows in the mountains surrounding it, acts as a regulator, with the result that the Yellowstone River is much more constant in its flow during the summer months than is usually the case with the intermountain streams. This river after leaving the National Park takes a northerly course into Montana, and thence easterly to its junction with the Missouri River. Besides its source, the Yellowstone has the supply of a number of smaller tributaries before entering the area surveyed.

The following table gives the discharge of the Yellowstone River at Livingston, about 115 miles above Billings, during the irrigating season, as recorded by the Hydrographic Division of the U. S. Geological Survey:

Mean monthly discharge of Yellowstone River at Livingston, Mont., in second-feet, for six months in 1898, 1900, 1901.

[Drainage area, 3,580 square miles.]

Month.	Year.		
	1898.	1900.	1901.
May	13,402	7,530	1,218
June	15,257	11,415	10,228
July	7,231	4,811	5,534
August	4,099	2,666	3,107
September	2,450	1,878	2,248
October	1,915	1,607	1,926

NOTE.—Records for 1899 incomplete.

The principal canal in the area, as well as the first to be constructed, is what is commonly known as the "Big Ditch," or officially as the Minnesota and Montana Improvement Ditch. The construction of this canal was begun in 1882. In 1890 it was rebuilt, giving it a present capacity of about 300 second-feet at the intake. Its length is 39 miles, extending from a few miles above Park City to Billings. It covers an area of 25,000 acres, of which fully three-fourths is irrigated. "Water right" in this ditch is obtained by purchasing stock, which is negotiable and not permanently attached to the land. The par value of the stock is $10 and the present selling price about $15. One share of stock calls for 1¼ miner's inches (40 miner's inches = 1 second-foot) continuous flow. A board of trustees elected by the stockholders manage the canal. The season of irrigation is approximately from May 1 to October 1. The loss by seepage and evaporation, which has been quite carefully determined, is approximately 25 per cent of the intake.

The Highland Ditch, which was being finished at the time of the survey, is a branch of the Minnesota and Montana Improvement Ditch and will irrigate about 5,000 acres.

Canyon Creek Ditch is smaller and was constructed in 1882–83. It originally had a capacity of about 50 second-feet, but was enlarged in 1891, and it now has a capacity of about 150 second-feet. It covers an area of about 10,000 acres, most of which is irrigated. It is also managed by a board of trustees elected by the stockholders.

The Italian Ditch is another smaller one, which irrigates part of the lower lands south of Park City.

The Suburban Ditch is about 5 miles long, has a capacity of 30 second-feet, and irrigates about 1,600 acres.

These canals or ditches all tap the Yellowstone River, and carry a good quality of irrigation water. A little irrigation is done, however, with seepage water, which, considering the quality, is a dangerous practice. The table following the chapter on seepage waters shows that such water carries considerable salt in solution. Water of this

character added to soils already alkaline only hastens the day when they must be abandoned. (See Pl. XL.)

As before stated, the irrigating water used in the area is of very good quality. The following table shows the chemical composition of the salt in the canal water:

Chemical analysis of water taken in Minnesota and Montana Improvement Ditch.

Constituent.	Per cent.	Constituent.	Per cent.
Ions:		Conventional combination:	
Calcium (Ca)	6.81	Calcium sulphate ($CaSO_4$)	22.73
Magnesium (Mg)	3.78	Magnesium chloride ($MgCl_2$)	5.30
Sodium (Na)	14.40	Magnesium bicarbonate $Mg(HCO_3)_2$	12.87
Potassium (K)	3.03	Potassium chloride (KCl)	6.81
Sulphuric acid (SO_4)	15.92	Sodium bicarbonate ($NaHCO_3$)	52.29
Chlorine (Cl)	7.57		
Bicarbonic acid (HCO_3)	48.49	Total solids, parts per 100,000	13.2

UNDERGROUND AND SEEPAGE WATERS.

A large number of samples of well, drainage, and spring waters were examined during the field work. All the samples contained considerable amounts of salts in solution. The well waters were particularly impure, the salt content in these varying from 170 to 900 parts in 100,000 parts of water. The table following gives analyses of typical samples gathered in all parts of the area. As the party had no means in the field of determining the sulphates quantitatively, these were tested for qualitatively only. All the samples carried considerable quantities of these latter salts.

As these samples were collected in all parts of the area, it will be seen that the subsoil water is quite generally impregnated with alkali. The wells having the highest salt contents are located in the level clay areas, where the soil texture is heavy to some depth, and in the alkaline areas, where the subsoil water is near the surface. All of the better wells are located on or near the gravel terrace, as would be expected, the underdrainage here being comparatively good. Some areas here and there are not represented in this table, as the people make no attempt to get well water, knowing the general character of it.

Many springs were found along the river bank and below the gravel terrace, and a few of these were examined. Some were much better than the well waters, but as a general rule they were too salty for use.

This condition of the subsoil and drainage waters indicates forcibly both insufficient undergound drainage and the existence of accumulations of salt in the subsoil. Such strongly alkaline solutions could hardly exist in all the wells were the underground drainage good, and the springs would not be so generally salty were there no accumulations of salt in the deep subsoil.

Chemical analyses of typical samples of well, drainage, and spring water.

No. of sample.	Location.	Depth.	Parts of salt per 100,000.		
			Total salt content.	Bicar-bonates.	Chlo-rides.
		Feet.			
11	S. center sec. 5, T. 1 S., R. 26 E	4	670	176	62
24	S. center SW. ¼ sec. 36, T. 1 N., R. 25 E	10	700	68	16
25	¼ mile W. of SE. corner sec. 36, T. 1 N., R. 25 E	8	144	72	7
44	Center sec. 10, T. 1 S., R. 26 E	10	111	50	7
47	S. center sec. 9, T. 1 S., R. 26 E		681	80	24
54	W. center sec. 17, T. 1 S., R. 26 E	15	500	67	14
55	¼ mile S. of NE. corner sec. 19, T. 1 S., R. 26 E		400	68	16
68	S. center sec. 2, T. 1 S., R. 25 E	12	670	55	23
80	NW. corner sec. 24, T. 1 S., R. 25 E	14	890	161	46
87	⅛ mile N. of SW. corner sec. 5, T. 1 S., R. 25 E	5	440	83	7
100	NW. corner sec. 3, T. 1 S., R. 25 E	15	690	55	12
116	SW. corner sec. 20, T. 1 S., R. 25 E		400	53	19
120	Near E. center sec. 31, T. 1 S., R. 25 E	8	200	67	9
169	Near SE. corner sec. 24, T. 2 S., R. 23 E	4	172	67	12
174	Near center sec. 8, T. 2 S., R. 24 E	3	880	63	12
17	¼ mile W. of NE. corner sec. 4, T. 1 S., R. 26 E. (drain)		168	42	6
19	E. center sec. 31, T. 1 N., R. 26 E. (drain)		220	63	2
27	S. center sec. 31, T. 1 N., R. 26 E. (spring)		482	23	11
63	¾ mile W. of NE. corner sec. 1, T. 1 S., R. 25 E. (drain)		500	70	83
161	Near center NE. ¼ sec. 7, T. 2 S., R. 24 E. (drain)		170	43	5
173	Near center sec. 8, T. 2 S., R. 24 E. (spring)		450	52	7

Laboratory analyses of sample 47 in preceding table.

Constituent.	Per cent.	Constituent.	Per cent.
Ions:		Conventional combination:	
Calcium (Ca)	7.11	Calcium sulphate ($CaSO_4$)	24.16
Magnesium (Mg)	4.84	Magnesium sulphate ($MgSO_4$)	24.01
Sodium (Na)	15.86	Potassium chloride (KCl)	1.92
Potassium (K)	1.01	Sodium chloride (NaCl)	2.23
Sulphuric acid (SO_4)	62.17	Sodium bicarbonate ($NaHCO_3$)	9.29
Chlorine (Cl)	2.26	Sodium carbonate (Na_2SO_4)	38.39
Bicarbonic acid (HCO_3)	6.75	Total solids, parts per 100,000	681.5

ALKALI IN SOILS.

The alkali map accompanying this report shows the mathematical mean percentage of soluble salts, at soil saturation, of the first 6 feet of soil. This salt content was determined by the electrolytic bridge. Where the vertical distribution of the salt was uniform only the first, third, and fifth foot sections were determined, but in any other case every foot of soil was tested. While the alkali map represents only the first 6 feet, many deeper borings were made to determine the distribution of salt at greater depths.

A comparison of this map with the soil map will show that in general the most alkali is found in the areas classified as Billings clay and

Billings loam. Alkali is not, however, found in all of the clay areas, as some of these have a light subsoil giving good underground drainage. But wherever the clay extends to a depth of 5 or 6 feet or more, alkali is found. The only exception to this is in the southwestern part of T. 1 S., R. 24 E., where the clay extends to 6 feet or more without injurious amounts of salts.

The vertical distribution of the alkali varies much, this being governed by the texture of the soil and subsoil and by the position of the underground water. In the virgin alkaline clay areas the distribution is quite uniform below the first foot, with the maximum at about 5 feet below the surface. The clay areas in and around Laurel are illustrative of this. With a heavy soil and light subsoil the maximum salt content is in one of the first 3 feet of soil, depending upon the underground water conditions, with a notable decrease at greater depths. The alkali soils in and around Billings are of this kind. In the deep clay areas where irrigation has been moderate and well managed the maximum salt content is from the third to the sixth foot. The alkali areas in and around the western side of T. 1 S., R. 25 E., are of this description. On some of the bench lands and on the alkali soils along the river the maximum amount of alkali is found in the first or second foot, with generally an accumulation on the surface, due to evaporation of subsoil water, which is near enough the surface to be brought up by capillarity.

In 1898 a party from the Bureau of Soils made a study of the alkali soils around Billings, the results of which were published as Bulletin 14 of the Division of Soils. For this report a survey was made of a few square miles lying directly west of Billings and a detailed study was made of sec. 2, T. 1 S., R. 25 E. Lack of drainage was clearly shown to be the cause of the rise of the alkali, and a number of studies were made upon the effect of drains in removing the salt. At that time a few small drains were either in operation or being dug, and large quantities of salt were being carried away. These ditches have been allowed to fill up, and the alkali conditions have not improved since then.

In the unirrigated soils above the canal the amount of alkali in the first 6 feet is usually less than 0.20 per cent. Borings made in 1898 by the party already mentioned and borings made by the present party, as well as the determination made by Dr. Traphagen, showed this to be the general rule. Salts in moderate amounts are, however, often found at 7 or 8 feet below the surface, and generally increase downward. In one of the deeper borings made in sec. 13, T. 1 S., R. 24 E., in a heavy growth of grease wood, no injurious amounts of salts were found until the twelfth foot was reached. From there down to the sixteenth foot the soil was moist and carried considerable amounts of sulphates.

The source of the alkali found in the upper bench and most of that in the level area south of it is in the shales underlying the sandstone beds on the north side of the valley. The sandstone beds have also contributed a little, but by far the most of it came from the underlying shale. Exposures of this shale in the hills usually showed the walls covered with a deposit of salts, and many smaller beds and veins of salt—mostly calcium sulphate—were found in such places. The origin of the alkali in the Laurel sandy loam is mostly in the seepage water from the bench lands.

The composition of the alkali in the bench soils is quite uniform, consisting principally of sulphates, with small amounts of bicarbonates, chlorides, and some traces of alkaline carbonates. In boring up samples sulphates were often found in both the amorphous and crystalline forms, these having either separated out after the deposition of the soil or been transported as such with the soil. Traces of alkaline carbonates were sometimes found in the bench lands, but quite as often no trace could be detected. The only exception found to this was in sec. 8, T. 1 S., R. 26 E., where the first foot of soil contained about 1.80 per cent of total salt and a little less than 0.10 per cent of black alkali. The other places where black alkali was found were in the Laurel sandy loam, and this is undoubtedly formed from the hydrogen carbonates in solution in the seepage water. These areas carried from 0.05 per cent to 0.10 per cent of black alkali, with the exception of the small salt area in W. center sec. 31, T. 2 S., R. 23 E., which carried about 0.18 per cent of black alkali. These areas always had a surface deposit of white alkali, together with the black.

A noticeable feature in the composition of the alkali of this area is the remarkably small amounts of hydrogen carbonates present. This accounts for the small amounts of normal carbonates, or black alkali. Moreover, there seems to be none in the shale from which the alkali originated. Probably the reason for such small quantities of bicarbonates is due to some extent to the large amounts of sodium sulphate present, which, according to research work done in the Bureau laboratories, drives back the bicarbonates to the normal carbonates. The probable result in the soil would be the formation of lime carbonate.

The analyses of the standardization crusts and solution which follow show the predominating salts to be sulphates, mostly of sodium, this latter constituting from two-thirds to three-fourths of the total. Chlorides are not present in large amounts and estimable carbonates in only two of the crusts, these samples having been collected in the same place in the river bottom soils containing considerable amounts of seepage. It will be noticed that the area with the largest amounts of bicarbonates contains the smallest amount of sulphates, and vice versa.

In this connection it is of interest to compare some of the alkali conditions as they existed in 1898 and as they now are. The following

table gives data enabling such a comparison of some of the borings made in 1898 with others made in 1902:

Table showing alkali conditions of the soil in 1898 and 1902.

DETERMINATIONS MADE IN 1898.

No. of boring.	Location.	First foot.	Second foot.	Third foot.	Fourth foot.	Fifth foot.	Sixth foot.
		Per ct.	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*
65	¾ mile W. of NE. corner sec. 1, T. 1 S., R. 25 E.	0.57	0.49	0.34	....	(*a*)	(*a*)
66	¾ mile W. of NE. corner sec. 1, T. 1 S., R. 25 E.	.64	.38	.31	0.34	(*a*)	(*a*)
33	¼ mile W. of SE. corner sec. 2, T. 1 S., R. 25 E.	.19	.24	.44	.46	0.46	0.31
34	S. center sec. 2, T. 1 S., R. 25 E	.70	.52	.41	.32	.32	.27
40	S. center sec. 5, T. 1 S., R. 26 E	.35	.89	.23	.17	.20	....
11	Center NE. ¼ sec. 4, T. 1 S., R. 26 E	.10	.51	.28	.17	....	....
12	⅛ mile NW. of center sec. 4, T. 1 S., R. 26 E...	.32	.41	.41	.47	....	....

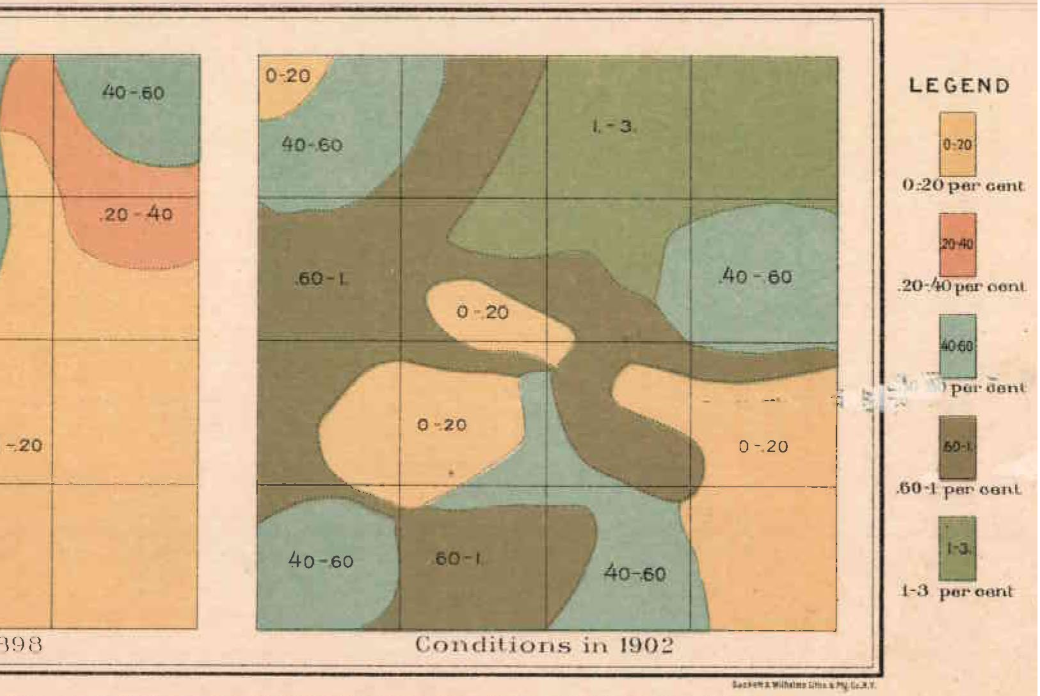
a Not determined.

DETERMINATIONS MADE IN 1902.

		Per ct.	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*
62	¾ mile W. of NE. corner sec. 1, T. 1 S., R. 25 E.	2.20	1.24	0.66	0.58	....	0.66
67	¼ mile W. of SE. corner sec. 2, T. 1 S., R. 25 E.	.54	.41	.51	.60	0.52	.40
69	S. center sec. 2, T. 1 S., R. 25 E	3.00	....	.45	....	.37	....
12	S. center sec. 5, T. 1 S., R. 26 E	.93	.56	.40	.30	....	.36
29	Center NE. ¼ sec. 4, T. 1. S., R. 26 E	.60	....	.25	....	.42	....
30	⅛ mile NW. of center sec. 4, T. 1 S., R. 26 E...	2.50	2.35	1.35	.98	1.20	....

As the method of determination—with the electrolytic bridge—was the same in both instances, these borings can be quite safely compared. It will be seen that the conditions in these places are much worse now than four years ago, as regards salt both on the surface and in the subsoil. This shows the uselessness of trying to wash the salts out of the surface soil by flooding while at the same time the subsoil water is continually bringing the salt to the surface.

From Pl. XLI, which shows graphically the alkali conditions existing in sec. 2, T. 1 S., R. 25 E., in 1898 and in 1902, it will be seen that very considerable changes in the distribution of the salts have taken place during the intervening period, and that the proportion of salt has generally increased. The climatic conditions in June, 1898, were, however, quite different from those in May, 1902. Nearly a whole season's rainfall fell in June, 1898, while the month of May, 1902, received but four or five days' heavy rain altogether. This, in connection with the fact that no irrigation had been done in 1902 before the area in this vicinity was examined, would undoubtedly have some influence on the distribution of the alkali, but could hardly account for the large differences found. This could, however, easily account for much of the difference in depth to standing water, which was nearer the surface in 1898 than in 1902.



25 E., AS CONSTRUCTED FROM BORINGS 6 FEET DEEP MADE IN 1898 AND AGAIN IN 1902.

The determinations made in 1898 by Dr. Traphagen, of the Montana experiment station, would also indicate that alkali conditions are worse now than at that time.

Chemical analyses of crusts used in standardization.

Constituent.	6600. Near NW. corner sec. 2, T. 1 S., R. 26 E., alkali crust 0 to 1 inch.	6601. Center sec. 10, T. 1 S., R. 26 E., soil 0 to 10 inches.	6602. Center sec. 10, T. 1 S., R. 26 E., alkali crust 0 to 1 inch.	6603. S. center sec. 9, T. 1 S., R. 26 E., alkali crust 0 to 1 inch.	6604. Center sec. 8, T. 1 S., R. 26 E., crust 0 to 1 inch.	6605. W. center sec. 34, T. 1 S., R. 26 E., alkali crust 0 to 1 inch.
Ions:	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
Calcium (Ca)	0.79	2.99	0.16	3.63	4.14	1.85
Magnesium (Mg)	1.79	.85	.24	2.01	2.57	2.95
Sodium (Na)	28.16	20.56	31.73	23.51	22.06	25.03
Potassium (K)	.72	9.63	.88	2.78	2.79	1.08
Sulphuric acid (SO_4)	67.73	45.85	59.93	62.98	61.06	66.49
Chlorine (Cl)	.33	Trace.	1.48	3.24	4.70	1.54
Bicarbonic acid (HCO_3)	.48	16.06	2.83	1.85	2.68	1.06
Carbonic acid (CO_3)	Tr.	4.06	2.75	....	....	....
Conventional combinations:						
Calcium sulphate ($CaSO_4$)	2.71	10.07	.55	12.29	14.00	6.08
Magnesium sulphate ($MgSO_4$)	8.90	4.06	1.22	9.91	12.76	14.58
Sodium sulphate (Na_2SO_4)	85.57	35.12	85.06	66.66	55.68	72.93
Potassium sulphate (K_2SO_4)	1.60	21.41	1.96	6.18	6.15	2.41
Sodium bicarbonate ($NaHCO_3$)	.67	22.06	3.90	2.55	3.69	1.46
Sodium carbonate (Na_2CO_3)	Tr.	7.28	4.87	....	....	....
Sodium chloride (NaCl)	.55	Tr.	2.44	5.41	7.72	2.54
Per cent soluble	44.68	0.934	17.00	2.59	1.79	9.04

Chemical analysis of standardization solution.

Constituent.	Per cent.	Constituent.	Per cent.
Ions:		Conventional combinations:	
Calcium (Ca)	0.89	Calcium sulphate ($CaSO_4$)	3.03
Magnesium (Mg)	1.83	Magnesium sulphate ($MgSO_4$)	9.06
Sodium (Na)	26.24	Potassium sulphate (K_2SO_4)	8.14
Potassium (K)	3.65	Sodium chloride (NaCl)	2.91
Sulphuric acid (SO_4)	63.68	Sodium carbonate (Na_2CO_3)	1.45
Chlorine (Cl)	1.76	Sodium bicarbonate ($NaHCO_3$)	1.56
Bicarbonic acid (HCO_3)	1.13	Sodium sulphate (Na_2SO_4)	73.85
Carbonic acid (CO_3)	.82		

RECLAMATION OF ALKALI SOILS.

As much of the area surveyed, especially the clay areas, was originally heavily charged with alkali, the whole blame for present conditions can not be laid to the seepage resulting from irrigation of the higher-lying lands. That the seepage and drainage waters are doing considerable damage, however, will be apparent by a study of the underground-water map and a consideration of the table of analyses

of subsoil water given in the chapter on "Underground and seepage waters." It will also be noticed that as a rule the alkaline areas where standing water is within 6 feet or so of the surface have a surface accumulation of salts. Exception to this will be found in the extremely wet areas where the subsoil water reaches the surface, as here the salt is being carried away in solution.

It is very important, then, to keep this subsoil water sufficiently far below the surface to prevent its being brought up by capillarity, as in such case the salts in solution must necessarily accumulate on the surface. The question resolves itself, therefore, into underdrainage. Of course, prevention is better than cure, and much of the area now badly affected by alkali need never have become so if good judgment had been used in the management of irrigation water. However, it is not always, perhaps seldom, that the land damaged has become so by the irrigation of the land itself, but rather by overirrigation of higher-lying lands and by seepage water from canals. It is a pity that there is no redress for the farmer whose land is ruined through no fault of his own. As matters stand, however, there is no permanent remedy except underdrainage when the land becomes affected by salts brought there by irrigation above.

A few people in the area are trying to "reclaim" the alkali soils by running an excess of water on the land, thinking thus to wash off the alkali. It is probably a great temptation to the farmer who has a piece of land resembling a winter landscape to run a continuous stream of water over it in the hope of washing off the salt. As the surface salt is dissolved by the process the land really has the appearance of having been benefited. As a matter of fact, some of the surface salt is washed off; but there is another side to the story. A cursory glance at the table of comparison of borings made in 1898 and 1902 shows that without exception there is more salt in these areas now than there was four years ago, and that surface accumulations are much more common in those areas now than then. The increase is due simply to the bringing up of more salts from below by the subsoil water. With the subsoil water at a safe distance below the surface this could not take place. The filling up of the soil interstices by saturating the soil, thereby raising the underground-water table, is what the farmer accomplishes when he attempts to "reclaim" the land by excessive irrigation, and he not only makes his own land worse, but also that of his neighbor below him.

When, however, good and rapid underdrainage is provided for the excess of water applied, this excess drains away and carries with it the excess of salts dissolved. This method of heavy irrigation on well-drained land has been used for the reclamation of alkaline and saline soils in other countries and has been found successful.

The writer was told by a number of farmers, to whom alkali was

evidently a new problem, that they intended to put salt on the soil to reclaim it. When told that they already had too much salt on the land, and that it would be worse than foolish to add more, they were not a little surprised. The question was often asked whether something could not be added to "kill the alkali." So far as known there is nothing that could be added to the soils of this area that would materially benefit them. The salts present are generally of the kinds less injurious to crops. There is practically no black alkali in the area, and so it would be useless to add gypsum, as some proposed, even if there was not plenty of gypsum already in the soils.

There is then left no method of reclamation but careful irrigation and thorough underdrainage. The farmers as a rule will not exercise care in irrigation, taking generally as much water as they can get; and underdrainage is expensive and tedious. Some drainage work has been done, but not a single instance was met with in the whole area where drainage had been given a fair trial. A number of 2-foot so-called drains had been dug in some of the worst affected areas, but as the surrounding land was not drained immediately the drains were allowed to fill up and were subsequently abandoned. It follows of necessity that such land as Billings clay must have time to drain, as the soil is very close textured. A drain just west of Billings is the best one in the area, but that also has not been kept clean and in good condition, though the land immediately alongside it has been benefited. Drains to be of real value should be dug deep enough to reach the underlying sand or sandy loam, or if that lies too far below the surface they should be at least 5 feet deep. It is important also to keep the drains constantly clean and in good order.

It must be admitted, however, that draining Billings clay in the areas where the soil is deep is very tedious, laborious, and expensive. It is said that it is cheaper to abandon the farms and buy elsewhere. Of course, so long as this condition exists there is but little incentive to reclaim the alkali lands. But such a condition can not last long in a region that is being developed as rapidly as the area surveyed.

However, many of the alkaline areas can be made to yield fair crops without artificial drainage by adapting the crops to the nature of the soil. By sowing shallow-rooted hay crops and gradually working the surface salt downward the land can finally be improved so that more exacting crops may be grown, though, of course, where the subsoil water is near the surface that must first be gotten rid of by drainage. Importance is sometimes ascribed to the growing crops, alfalfa, for instance, as factors in removing salt from the soil. It is true that much mineral matter is removed in this way, but it may be questioned if alfalfa or any other hay crop will take up much more injurious mineral matter on alkaline than on nonalkaline soils. It seems likely that the benefit is more largely due to the cultivation and careful

irrigation of the field than directly to the amount of injurious salts taken up by the plant.

The reclamation of the heavier types of soil at Billings will be very slow and probably expensive, very largely on account of the shortness of the irrigation season. The reclamation of the lighter soils is simpler and can be carried on more rapidly and at a lower cost.

The cost of tiling the land will be from $15 to $20 per acre. To this should be added the cost of flooding the land for one to two years before crops can be grown. The total cost of reclamation should not be more than $25 per acre, and when land is thus reclaimed it is insured from further damage by either rise of alkali or water.

AGRICULTURAL METHODS.

When the virgin soil is first broken up, which is done at any time of the year except winter, the first crop planted is usually alfalfa, with sometimes enough land reserved for grain, fruit, and vegetables for farm use. Grain is sometimes grown in rotation with vegetables and is the crop usually sown when an alfalfa field is plowed up. As a rule, however, very little attention is paid to rotation of crops, owing to the overshadowing importance of hay production.

The fields are allowed to remain in alfalfa for a considerable length of time, usually being plowed only when the yields appreciably decrease. Alfalfa, if not injured by alkali or unwise management in irrigation, will continue to yield profitably for many years, fields seeded fifteen or eighteen years ago giving as large yields now as ever.

Timothy and blue-joint grass are usually sown on the heavier soils and are seldom plowed up, but are reseeded and harrowed if necessary. Sometimes a dressing of fertilizer is applied at the time of seeding.

The Billings clay is not as a rule devoted to grain crops of any kind, the soil being of such a nature as to make cultivation difficult. An attempt is sometimes made to secure a stand of alfalfa on the more strongly alkaline clay soils when first brought under cultivation, but failure usually results, for these soils often carry a large percentage of salt in the surface foot. Some of the more shallow-rooted crops, such as timothy and blue joint, would do much better until the land is at least partially reclaimed. There is no trouble in getting a crop of blue-joint grass started where alfalfa would make but poor headway. Timothy was found growing in clay soil carrying an average of 0.93 per cent alkali in the first 6 feet, with nearly 0.90 per cent in the first foot, and it was quite common to find good timothy fields with such amounts of salts as these from 18 inches downward. By care in irrigation the alkali could be removed from and kept below the first foot or two, thus securing a good surface soil in which alfalfa would be able to secure a foothold. Alfalfa will itself withstand considerable alkali when once it is well established.

Sugar beets would also undoubtedly be a good crop to grow on some of the alkali soils, but as there is no factory in the area there is no way of disposing of them except for feed, which would hardly be profitable.

The alkaline soils of the area, even where very badly impregnated, are made use of for pasturage. (See Pl. XXXIX.) A number of grasses, among them foxtail grass, do well, and in their early stage of growth furnish excellent grazing, the young grass being very succulent. Foxtail is usually an intermediary growth between the cultivated crops, before the land becomes badly affected by alkali, and the worst stage, when salt grasses come in. Sweet clover is another crop which will withstand a remarkably large amount of alkali, though not as much as foxtail. While sweet clover becomes rank and woody in the later stages of its growth, it is good feed if grazed while young. A number of salt grasses also serve well for this purpose. Among them the ordinary salt grass is too well known to need special mention.

Flooding is practically the universal method of irrigating in the area, and it is undoubtedly the best method, considering the character of the soils and the crops raised. The heavier soils—Billings clay and some of the loam areas—take water quite slowly, which would make the furrow method a tedious process, besides entailing the loss of much water which would run off at the end of furrows without benefiting the land.

It was found after irrigation of some of the hayfields that the clay soils were wet to a depth of about 18 inches. This is a very good depth for timothy and blue joint, and such irrigation does not fill the subsoil with water and cause injurious rise of alkali. One such field carried on an average about 1.10 per cent of salt for the first 6 feet. The first foot contained but 0.15 per cent, the third 0.30 per cent, and the fifth about 2 per cent. This instance shows the necessity of careful management in irrigation, as the saturation of such soil to a depth sufficient to connect with the subsoil water would soon ruin the field. The perennial rye grass growing here was in splendid condition. A 9-foot boring was made in a similar kind of soil in a virgin state a short distance away. The first foot carried about 1.80 per cent, and from there down the amount of salt increased to the sixth foot. By management similar to that of the field previously mentioned there is no reason why in a short time this virgin land should not be made to yield good crops of the shallow-rooted grasses. Grain seeded on similar soil a few rods away made a very poor growth.

This emphasizes the necessity of suiting the crops to the soils, considering all conditions which affect the crops, such as the texture of the soil and subsoil, amount of alkali, and whether this is uniformly distributed or found accumulated in the surface soil or subsoil. An instance is cited of a farmer who tried for four years to grow vege-

tables on the kind of soil just mentioned—Billings clay—with large amounts of salt near and at the surface. After that length of time he became bankrupt and moved away. Alfalfa was then tried with indifferent success; rye grass or timothy and blue joint would have done well on this field.

The areas of Billings clay having sandy loam or sand 2 feet or so below the surface would, however, be good for alfalfa, even where the virgin soil does carry considerable salt, as this may soon be moved into the lighter soil underneath by irrigation. As stated in the discussion of alkali in soils, such areas, when cultivated, seldom if ever carried injurious amounts of salt. Again, the planting of deep-rooted crops, such as alfalfa, in fields with light surface soil and clay within 18 or 24 inches containing large amounts of salt is not apt to give gratifying results, as alfalfa will soon show signs of decline with only 18 to 24 inches of good feeding depth. Irrigation on such soils usually increases rather than diminishes the salt content in the subsoil, especially with poor drainage.

The need of the stockmen for a great quantity of winter forage for their cattle and sheep has turned the attention of the farmers of the area to the production of hay almost to the entire exclusion of grain and other general farm crops. Alfalfa of course is the most important hay crop, but timothy and blue joint are also valuable, both for hay and pasturage. Some grain is grown, but the industry holds but a minor place in the local husbandry. Vegetables and fruit do well on some of the soils, so far as attempts at their cultivation have been made. There is as yet no fruit industry, but during the last year or two some orchards of apples, cherries, and plums have been set out. The prize peaches of the State were raised in the Yellowstone Valley in an orchard near Park City. This particular case is, however, an exceptional one, as generally speaking the valley is not a peach-raising district.

Yields of alfalfa vary considerably, depending on the character of soil and the care given it. Three and one-half to 7 or 8 tons per acre are sometimes grown, and the average is not far from 5 tons per acre in 3 cuttings. The yields of 7 or 8 tons are rather exceptional, being usually obtained on favorably situated, light, nonalkaline soils. Prices obtained for this crop vary, of course, with the severity of the winter and the consequent demand for hay by stockmen, but the usual price is from \$3.50 to \$4 per ton in the stack. The stockmen often make arrangements with the rancher to feed the hay to the stock during the winter, in which case a little more is paid.

Timothy and blue joint are not considered as good for winter feeding as alfalfa, and the yield is perhaps on the average not more than from 1 ton to 1½ tons per acre. The value of these grasses lies not only in the hay product, but also in the excellent pasturage which they

furnish after the hay crop is harvested. The fields are often used exclusively for pastures the heavy soils forming a very firm sod and retaining moisture well.

Clover has so far received but little attention, but is now being more generally introduced, though it is not likely ever to replace alfalfa to any great extent.

AGRICULTURAL CONDITIONS.

Generally the farmer or rancher owns his own place and works it himself, hiring labor according to the needs of the work. In some cases farms are leased, the lessor receiving a certain share of the products of the farm. The farms, as a general rule, are well cared for, although haphazard methods are occasionally met with, especially in farming alkali lands, and gross negligence is often seen in the management of irrigation water. This is, however, not always due to lack of intelligence, but to indifference, the majority of the farmers having enough to care for without putting much effort into cultivating land that does not promise good returns. The people are, generally speaking, energetic, wide awake, and prosperous. The average size of the farms is probably about 160 acres, though there are many ranches containing several sections of land.

Transportation facilities are good, the Northern Pacific Railway passing through the entire valley and furnishing four shipping points. However, the principal market for the leading crop (hay) is right at home. The bulk of the crop is consumed by the large herds of sheep and cattle that are brought down to the valley to be fed during the winter. Billings, a very thriving city, is the chief shipping point in the valley, as well as one of the most important in the State. Many cattle and sheep are annually shipped from there over the Northern Pacific and Burlington and Missouri railroads, of which Billings is the western terminus.

Most of the agricultural development of the area has taken place since 1892. The progress has been quite rapid since then and is still continuing, with the prospects that the area will have a very successful future.

Accessibility Statement

The Natural Resources Conservation Service (NRCS) is committed to making its information accessible to all of its customers and employees. If you are experiencing accessibility issues and need assistance, please contact our Helpdesk by phone at (800) 457-3642 or by e-mail at ServiceDesk-FTC@ftc.usda.gov. For assistance with publications that include maps, graphs, or similar forms of information, you may also wish to contact our State or local office. You can locate the correct office and phone number at http://offices.sc.egov.usda.gov/locator/app.

The USDA Target Center can convert USDA information and documents into alternative formats, including Braille, large print, video description, diskette, and audiotape. For more information, visit the TARGET Center's Web site (http://www.targetcenter.dm.usda.gov/) or call (202) 720-2600 (Voice/TTY).

Nondiscrimination Policy

The U.S. Department of Agriculture (USDA) prohibits discrimination against its customers, employees, and applicants for employment on the basis of race, color, national origin, age, disability, sex, gender identity, religion, reprisal, and where applicable, political beliefs, marital status, familial or parental status, sexual orientation, whether all or part of an individual's income is derived from any public assistance program, or protected genetic information. The Department prohibits discrimination in employment or in any program or activity conducted or funded by the Department. (Not all prohibited bases apply to all programs and/or employment activities.)

To File an Employment Complaint

If you wish to file an employment complaint, you must contact your agency's EEO Counselor (http://directives.sc.egov.usda.gov/33081.wba) within 45 days of the date of the alleged discriminatory act, event, or personnel action. Additional information can be found online at http://www.ascr.usda.gov/complaint_filing_file.html.

To File a Program Complaint

If you wish to file a Civil Rights program complaint of discrimination, complete the USDA Program Discrimination Complaint Form, found online at http://www.ascr.usda.gov/complaint_filing_cust.html or at any USDA office, or call (866) 632-9992 to request the form. You may also write a letter containing all of the information requested in the form. Send your completed complaint form or letter by mail to

U.S. Department of Agriculture; Director, Office of Adjudication; 1400 Independence Avenue, S.W.; Washington, D.C. 20250-9419; by fax to (202) 690-7442; or by email to program.intake@usda.gov.

Persons with Disabilities

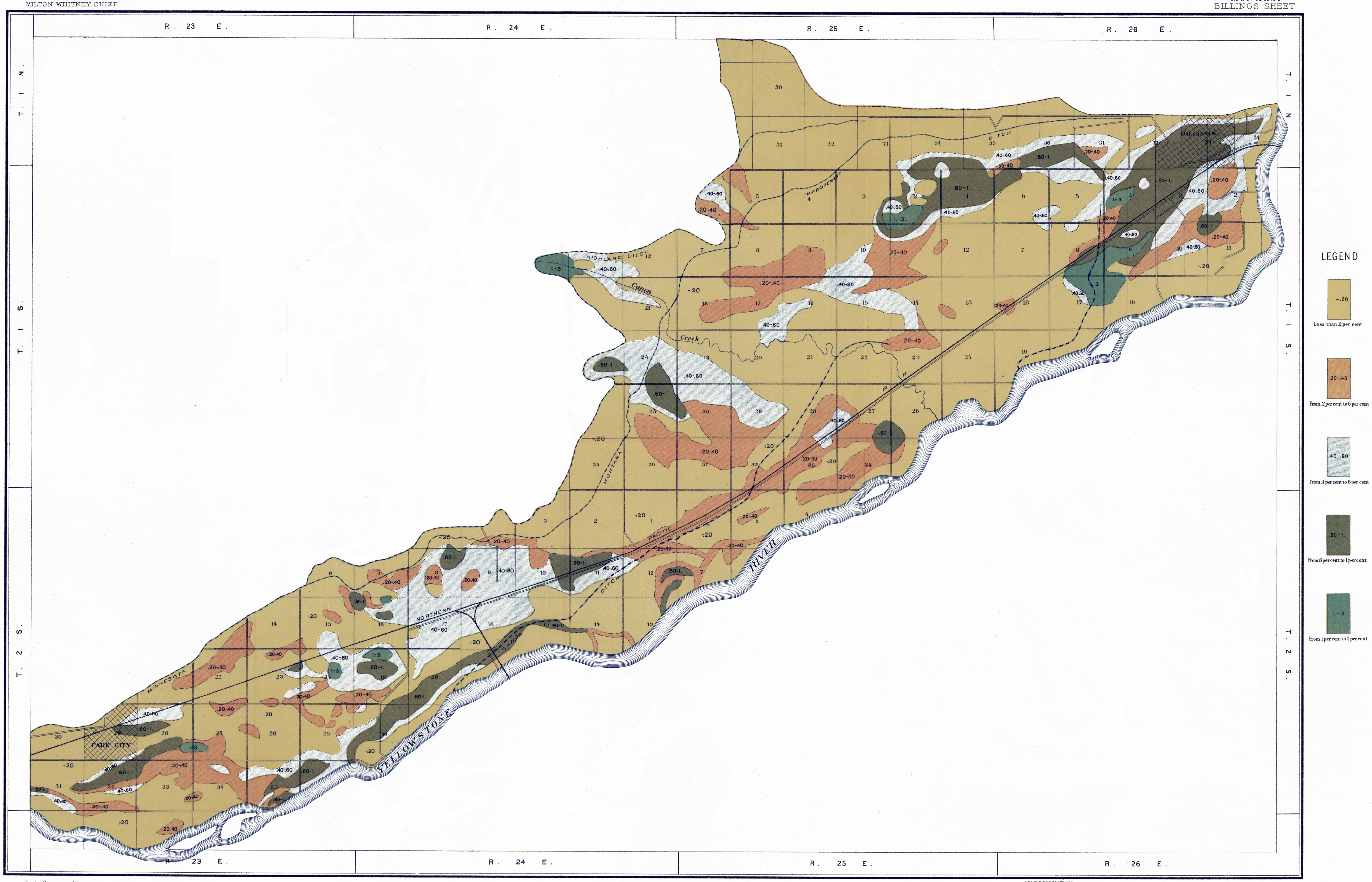
If you are deaf, are hard of hearing, or have speech disabilities and you wish to file either an EEO or program complaint, please contact USDA through the Federal Relay Service at (800) 877-8339 or (800) 845-6136 (in Spanish).

If you have other disabilities and wish to file a program complaint, please see the contact information above. If you require alternative means of communication for program information (e.g., Braille, large print, audiotape, etc.), please contact USDA's TARGET Center at (202) 720-2600 (voice and TDD).

U. S. DEPT. OF AGRICULTURE
BUREAU OF SOILS
MILTON WHITNEY, CHIEF.

ALKALI MAP

MONTANA
BILLINGS SHEET



Soils Surveyed by
Chas. A. Jensen and N. P. Neill
1902

Scale 1 inch - 1 mile

JULIUS BIEN & CO. LITH. N.Y.

Field Operations
Bureau of Soils
1902

U. S. DEPT. OF AGRICULTURE
BUREAU OF SOILS
MILTON WHITNEY, CHIEF.

SOIL MAP

MONTANA
BILLINGS SHEET

Soils Surveyed by
Chas. A. Jensen and N. P. Neill
1902

Scale 1 inch - 1 mile

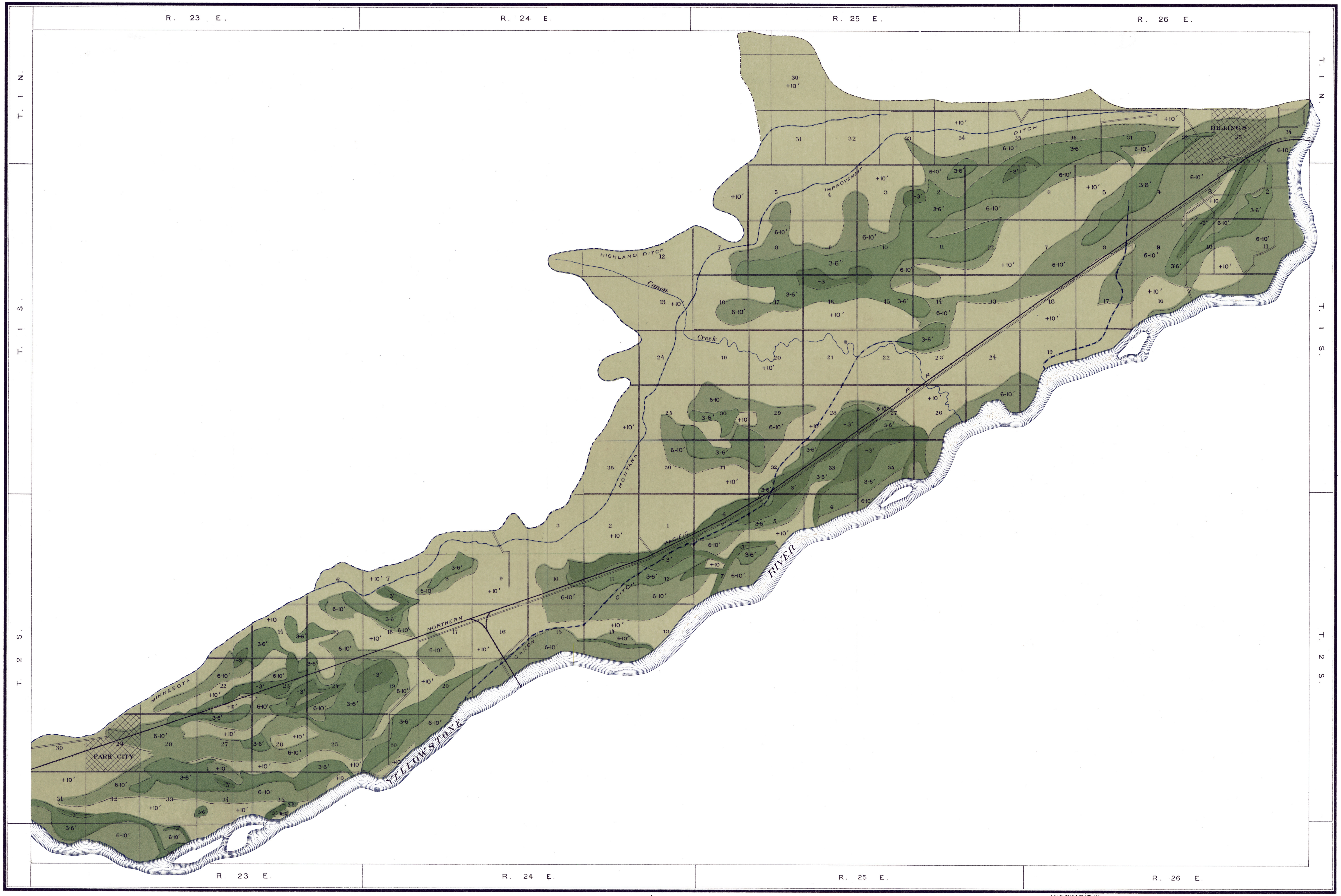
JULIUS BIEN & CO. LITH. N.Y.

Field Operations
Bureau of Soils
1902

U S DEPT OF AGRICULTURE
BUREAU OF SOILS
MILTON WHITNEY, CHIEF

UNDERGROUND WATER MAP

MONTANA
BILLINGS SHEET



LEGEND

-3′
Water less than 3 feet below surface

3-6′
Water from 3 feet to 6 feet below surface

6-10′
Water from 6 feet to 10 feet below surface

+10′
Water over 10 feet below surface

Water Surveyed by
Chas. A. Jensen and N. P. Neill
1902

Scale 1 inch = 1 mile

JULIUS BIEN & CO. LITH. N.Y.

Field Operations
Bureau of Soils
1902